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Parts of the Human Skull

- **Calvarium**, includes the brain case.
- **Cranium**, includes the face and the calvarium.
- **Mandible**, the lower jaw.
- **Skull**, includes both the cranium and mandible.

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Bones of the Skull

- **Ethmoid bone**, sieve-like spongy bone located in the anterior part of the floor of the cranium between the orbits. The ethmoid is the principal supporting structure of the nasal cavity.
- **Frontal bone**, forms the forehead, the roofs of the orbits, and most of the anterior part of the cranial floor.
- **Inferior Nasal Conchae**, one of three scroll-like bones that project from the lateral wall of the nasal cavity. The inferior nasal conchae articulate with the ethmoid, maxilla, lacrimal and paltine bones and form the lower part of the lateral wall of the nasal cavity.
- **Lacrimal bone**, a thin scalelike bone, roughly resembling a fingernail in size and shape, at the anterior part of the medial wall of the orbit, articulating with the frontal and ethmoidal bones and the maxilla and inferior nasal concha.
- **Mandible**, the bone forming the lower jaw; the largest and strongest bone of the face, presenting a body and a pair of rami, which articulate with the skull at the tempromandibular joints.
- **Maxillae**, paired bones uniting to form the upper jawbone. The maxillae articulate with every bone of the face except the mandible, or lower jawbone.
- **Nasal bone**; small oblong bones that meet at the middle and superior part of the face. Their fusion forms the superior part of the bridge of the nose.
- **Occipital bone**, a single trapezoid-shaped bone situated at the posterior and inferior part of the cranium.
- **Palatine bone**, one of two irregularly shaped bones (L-shaped) forming the posterior part of the hard palate, the lateral wall of the nasal fossa between the medial pterygoid plate and the maxilla, and the posterior part of the floor of the orbit. The posterior part of the hard palate, which separates the nasal cavity from the oral cavity, is formed by the horizontal plates.
- **Vomer**, a roughly triangular bone that forms the inferior and posterior of the nasal septum.
- **Parietal bones**, one of the two quadrilateral bones on either side of the cranium forming part of the superior and lateral surfaces of the skull, and joining each other in the midline at the sagittal suture. The parietal bones form the greater portion of the sides and roof of the cranial cavity.
- **Sphenoid bone**, a single, irregular, wedge-shaped bone at the base of the skull, which forms a part of the floor of the anterior, middle, and posterior cranial fossae. This bone is referred to as the keystone of the cranial floor because it articulates with all the other cranial bones.
- **Temporal bone**, one of the two irregular bones on either side of the skull forming part of the lateral surfaces and base of the skull, and containing the

organs of hearing. The temporal bones form the inferior sides of the cranium and part of the cranial floor.

- **Zygomatic bone**, the triangular bones on either side of the face below the eyes, commonly referred to as the cheekbones, they form the prominences of the cheeks and part of the outer wall and floor of the orbits.

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Bone Morphology

- **Crest**, a narrow prominent ridge.
- **Condyle**, a smooth rounded projection for articulation with another bone.
- **Epiphysis**, the end of a long bone that is originally separated from the main bone by a layer of cartilage but that later becomes united to the main bone through ossification [compare to suture and syphysis].
- **Foramen**, a true hole in the bone [e.g. foramen magnum, incisive foramen].
- **Line**, a narrow raised ridge.
- **Meatus**, a small tubular opening.
- **Sulcus**, a groove.
- **Suture**, the line formed by the junction of two bones or an immovable joint between two bones, especially of the skull [compare to epiphysis and syphysis].
- **Syphysis**, the line or junction formed by a cartilaginous articulation between two bones without an intervening synovial membrane, this articulation often fuses as in the two bones and the two halves of the mandibles [compare to suture and epiphysis].
- **Trochanter**, a large rounded projection for muscle attachment.

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pons (pons) (ponz) gen. *pon'tis* pl. *pon'tes* [L. "bridge"] [TA] 1. bridge: any slip of tissue connecting two parts of an organ. 2. the part of the central nervous system lying between the medulla oblongata and the mesencephalon, superior to the cerebellum; it consists of an anterior and a posterior part (see *pars basilaris pontis* and *tegmentum pontis*). Called also *p. cerebelli*. See Plate 11. See also *brainstem*.

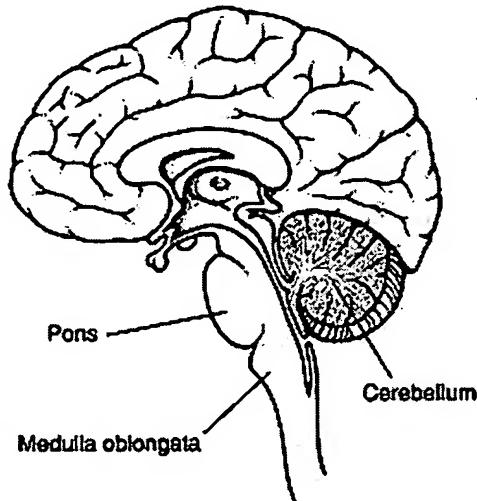


Figure P-54

pons cerebel'li, pons (def. 2).

pons et cerebel'lum, TA alternative for *metencephalon* (def. 1).

pons he'patis, an occasional projection of fibers partially bridging the longitudinal fissure of the liver.

pontile (pon·tile) (pon't[imacr]l, pon't[emacr]l) pertaining to the pons; pontine.

pontine (pon·tine) (pon't[imacr]n, pon't[emacr]n) pertaining to the pons; pontile.

DOCUMENT-IDENTIFIER: US 6272370 B1

TITLE: MR-visible medical device for neurological interventions using nonlinear magnetic stereotaxis and a method imaging

Abstract Text (1):

The present invention comprises a device and method for targeted drug delivery, and especially intracranial infusion or retroperfusion drug delivery using nonlinear magnetic stereotaxis in combination with magnetic resonance (MR) imaging and/or X-ray visualization. An MR-visible and/or X-ray visible drug delivery device is positioned by non-linear magnetic stereotaxis at a site such as an intracranial target site, its location is verified via MR imaging, and it is then used to deliver a biologically active material such as a diagnostic or therapeutic drug solution into that site (such as the brain) at constant or variable rates. The spatial distribution kinetics of the injected or infused drug agent may be monitored quantitatively and non-invasively using real-time MR-imaging such as water proton directional diffusion MR imaging, to establish the efficacy of targeted drug delivery.

Brief Summary Text (22):

One recently established method of reading the data obtained from the MR imaging is technically founded upon existing knowledge of Apparent Diffusion Coefficients (ADC) in particular regions of the body. There is significant published literature with respect to ADC values for specific tissues in various parts of animals, including various tissues of humans (e.g., Joseph V. Hajnal, Mark Doran, et al., "MR Imaging of Anisotropically Restricted Diffusion of Water in the Nervous System: Technical, Anatomic, and Pathological Considerations," *Journal of Computer Assisted Tomography*, 15(1): 1-18, January/February, 1991, pp. 1-18). It is also well established in the literature that loss of tissue structure through disease results in a decrease of the ADC, as the tissue becomes more like a homogeneous suspension. Clinical observations of changes in diffusion behavior have been made in various tissue cancers, multiple sclerosis, in strokes (where the reduction in diffusion precedes the increase in T2), and in epilepsy. (e.g., Y. Hasegawa, L. Latour, et al. "Temperature Dependent Change of Apparent Diffusion Coefficient of Water in Normal Ischemic Brain", *Journal of Cerebral Blood Flow and Metabolism* 14:389-390, 1994). Thus, ADC values are specific for specific types of tissues. Accordingly, as different drugs/chemicals are introduced into a tissue volume under MR observation, the change in ADC resulting from each drug/chemical interaction with the ambient water proton environment can be observed.

Detailed Description Text (4):

The invention comprises a device and method for targeted intracranial drug delivery using nonlinear magnetic stereotaxis combined with real-time magnetic resonance (MR) imaging or X-ray visualization guidance and, where appropriate, additional use of conventional methods of catheter manipulation. In one preferred embodiment, the MR-visible catheter drug delivery device is guided into the distal cerebrovasculature using a combination of flow-directed, manual manipulation, and magnetic stereotaxis steering without reducing cerebral perfusion in the affected vascular territory. Some general features of magnetic stereotaxis or magnetic surgical procedures are described in the text that follows. Specific procedures will depend on the nature of the patient's malady, the location and accessibility of the lesion or target location, and the mode of use selected by the clinical operator of the magnetic stereotaxis or magnetic surgery system. In a nonlinear magnetic stereotaxis procedure, the following procedures, with desired clinical variations, provide an example of practice of the present invention. The patient may be first fitted with fiducial markers that are fixed to the skull and which are visible in both MR and x-ray images. After these markers are placed in an appropriate array on the skull, the patient is given a pre-operative MR brain scan, the results of which constitute an atlas of images that define the location of critical brain structures and any potential target locations (e.g., a specific part of a tumor) relative to the fixed fiducial markers. The atlas of images is then stored in the host computer system used by the

clinician to control the magnetic stereotaxis system. Near real time, real time, or on-the-fly MR images may also be obtained and might be used to control the magnetic stereotaxis system (although this would interrupt the magnetic stereotaxis procedure to some and perhaps a large degree), and in fact, real time images provide a potentially more accurate guide path. Following any additional pre-operative procedures that might be indicated for the patient's condition (eg., sedation, fall or partial anesthesia, etc.), the patient who will undergo an intraparenchymal magnetic surgery has a burr hole opened in their skull to allow the clinician an access port to insert the implant that will be magnetically guided to the intracranial target. Following placement of the implant on the pial surface of the brain within and at the bottom of the burr hole, the patient then rests their head within the configuration of coils that are used to apply magnetic forces and torques to the implant, and the clinician operates the bi-planar fluoroscopy system and other controls of the magnetic stereotaxis system. The resulting images provide 3-dimensional information about the location of the implant relative to the skull markers, and these data are superimposed and registered onto the pre-operative MR brain scan (near real time, real time or a more recent scan) so that the clinician can determine the initial position of the implant in relation to critical brain structures and/or target locations within the brain. The clinician then enters commands into the magnetic stereotaxis system's user interface that instruct the system how far to move the implant and in what specific direction. This can be done in one instance by using cursor-cross hairs, screen contact pencils, virtual drawing systems, or other graphic or viewable drafting systems on a computer screen to indicate the present location of the implant's tip and to select the next location to which it is to be moved. The clinician then instructs the system to execute this movement command and the system uses its control algorithm to produce magnetic fields that steer the magnetic tip of the implant appropriately while the body of the implant is pushed forward, as might be done by a motor-actuated guide-wire that traverses the interior of the implant/catheters/lumen, and abuts against the rear side of the tip of the implant. Biplanar fluoroscopic images are obtained during the movement sequence to localize the new position of the tip of the implant. In some variations of this procedure and with reference to prior art cited above, a multiple lumen catheter is used as the implant, and the magnetic tip of the catheter (fixed to one of the interior sub-catheters) can then be withdrawn from the implant once it is properly in place, and some other mechanism or therapy deliver device can be inserted through the outermost lumen of the catheter in place of it to perform the indicated diagnostic or therapeutic task. The implant can then either be withdrawn or left in place for any subsequent treatments that might be needed.

Detailed Description Text (22):

There is currently considerable interest in the therapeutic use of small ions as well as macromolecules in the treatment of various neurologic diseases. To be effective, such molecules must be able to reach target tissue receptors. Many molecules that are used in therapeutic drugs are large in size, for example, neuroleukin, a neuromodulator drug tested for treatment of amyotrophic lateral sclerosis is about 56 kDa, bethanechol chloride used in treatment of Alzheimer's Disease is about 196 kDa and nerve growth factor is about 13 kDa. While the importance of large molecular weight molecules in direct parenchymal drug therapy is growing, little is known about the time course and the spatial range of their actions, since dynamic visualization methods for studying the spread of macromolecular species within the brain are not typically available.

Detailed Description Text (48):

The method of the invention can be used within a wide range of medical procedures as in, for example, a) providing for a temporary life-support system in stroke patients based on microcatheter retroperfusion of acutely ischemic brain tissue using nonlinear magnetic stereotaxis and MR imaging and/or X-ray guidance; b) for catheter -based administration of thrombolytic agents, MR-visible contrast media, or cerebroprotective anti-ischemia drugs, such as sodium and calcium neuronal membrane channel blockers, NMDA antagonists, glycine partial agonists, adenosine agonists and antagonists, calpain inhibitors, endothelin antagonists, antiadhesion antibodies, antiphospholipid antagonists, and nitric oxide derivatives linked to blood-brain barrier transport vectors, such as liposomes, or perhaps to blood-brain

barrier permeabilizing agents; c) for pre- and post-surgical endovascular treatment of tumors of the brain by acute, subacute and chronic infusion of therapeutic drug agents, neurotoxins, anti-angiogenesis factors, devascularization embolotherapy agents, anti-emetics, and anti-nausea agents linked to blood-brain barrier transport vectors, such as liposomes or blood-brain barrier permeabilizers; d) the catheter device can be used as a modified stent device to preserve the patency of intracranial venous blood vessels and sinuses which are either blocked by plaques or mechanically compressed by brain tumors, trauma, infection, or edematous masses; e) the MR-visible drug delivery device can also be used to treat non-ischemic cerebral lesions, such as the plaques associated with multiple sclerosis and Alzheimer's disease, by targeted endovascular or intraparenchymal injection or infusion of neuropeptides, monoclonal antibodies and other gene-targeted therapies, growth factors, and other therapeutic agents, which may be linked to various bloodbrain transport vectors, such as liposomes or blood-brain barrier permeabilizers.

Other Reference Publication (14):

Howard, M.A., "Stereotaxic pallidotomy for the treatment of Parkinson's Disease", Current Surgery, 54 (1), 31-34, (Jan. 1997).

Parts of the Human Skull

- **Calvarium**, includes the brain case.
- **Cranium**, includes the face and the calvarium.
- **Mandible**, the lower jaw.
- **Skull**, includes both the cranium and mandible.

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Bones of the Skull

- **Ethmoid bone**, sieve-like spongy bone located in the anterior part of the floor of the cranium between the orbits. The ethmoid is the principal supporting structure of the nasal cavity.
- **Frontal bone**, forms the forehead, the roofs of the orbits, and most of the anterior part of the cranial floor.
- **Inferior Nasal Conchae**, one of three scroll-like bones that project from the lateral wall of the nasal cavity. The inferior nasal conchae articulate with the ethmoid, maxilla, lacrimal and paltine bones and form the lower part of the lateral wall of the nasal cavity.
- **Lacrimal bone**, a thin scalelike bone, roughly resembling a fingernail in size and shape, at the anterior part of the medial wall of the orbit, articulating with the frontal and ethmoidal bones and the maxilla and inferior nasal concha.
- **Mandible**, the bone forming the lower jaw; the largest and strongest bone of the face, presenting a body and a pair of rami, which articulate with the skull at the tempromandibular joints.
- **Maxillae**, paired bones uniting to form the upper jawbone. The maxillae articulate with every bone of the face except the mandible, or lower jawbone.
- **Nasal bone**, small oblong bones that meet at the middle and superior part of the face. Their fusion forms the superior part of the bridge of the nose.
- **Occipital bone**, a single trapezoid-shaped bone situated at the posterior and inferior part of the cranium.
- **Palatine bone**, one of two irregularly shaped bones (L-shaped) forming the posterior part of the hard palate, the lateral wall of the nasal fossa between the medial pterygoid plate and the maxilla, and the posterior part of the floor of the orbit. The posterior part of the hard palate, which separates the nasal cavity from the oral cavity, is formed by the horizontal plates.
- **Vomer**, a roughly triangular bone that forms the inferior and posterior of the nasal septum.
- **Parietal bones**, one of the two quadrilateral bones on either side of the cranium forming part of the superior and lateral surfaces of the skull, and joining each other in the midline at the sagittal suture. The parietal bones form the greater portion of the sides and roof of the cranial cavity.
- **Sphenoid bone**, a single, irregular, wedge-shaped bone at the base of the skull, which forms a part of the floor of the anterior, middle, and posterior cranial fossae. This bone is referred to as the keystone of the cranial floor because it articulates with all the other cranial bones.
- **Temporal bone**, one of the two irregular bones on either side of the skull forming part of the lateral surfaces and base of the skull, and containing the

organs of hearing. The temporal bones form the inferior sides of the cranium and part of the cranial floor.

- **Zygomatic bone**, the triangular bones on either side of the face below the eyes, commonly referred to as the cheekbones, they form the prominences of the cheeks and part of the outer wall and floor of the orbits.

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Bone Morphology

- **Crest**, a narrow prominent ridge.
- **Condyle**, a smooth rounded projection for articulation with another bone.
- **Epiphysis**, the end of a long bone that is originally separated from the main bone by a layer of cartilage but that later becomes united to the main bone through ossification [compare to suture and symphysis].
- **Foramen**, a true hole in the bone [e.g. foramen magnum, incisive foramen].
- **Line**, a narrow raised ridge.
- **Meatus**, a small tubular opening.
- **Sulcus**, a groove.
- **Suture**, the line formed by the junction of two bones or an immovable joint between two bones, especially of the skull [compare to epiphysis and symphysis].
- **Symphysis**, the line or junction formed by a cartilaginous articulation between two bones without an intervening synovial membrane, this articulation often fuses as in the two bones and the two halves of the mandibles [compare to suture and epiphysis].
- **Trochanter**, a large rounded projection for muscle attachment.

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